1 TITLE OF THE INVENTION

2 VEHICLE SURROUNDINGS MONITORING APPARATUS AND TRAVELING CONTROL

3 SYSTEM INCORPORATING THE APPARATUS

4

5 BACKGROUND OF THE INVENTION

6 1.   Field of the invention

7   The present invention relates to a vehicle surroundings

8 monitoring apparatus employing together a monitoring technique

9 on the base of images and a monitoring technique using radar data

10 and a traveling control system incorporating the apparatus.

11 2.   Discussion of related arts

12   In recent years, such vehicle surroundings monitoring

13 apparatuses as detecting traveling circumstances in front of an

14 own vehicle by means of processing images taken by a camera mounted

15 on a vehicle and the like and detecting information about a preceding

16 vehicle traveling ahead of the own vehicle from the traveling

17 circumstances, have been proposed. Further, various traveling

18 control systems in which a follow-up control to the preceding

19 vehicle or an intervehicle distance control between the own

20 vehicle and the preceding vehicle are performed using such vehicle

21 surroundings monitoring apparatuses, have been put into practical

22 use.

23   In these vehicle surroundings monitoring apparatuses

24 sometimes the ability of recognizing the preceding vehicle and

25 the like is exacerbated due to adverse conditions such as rain,
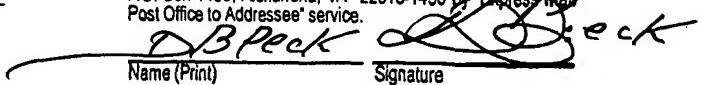
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snow, fog, backlight, knighting driving and the like. Japanese Patent Application Laid-open No. Toku-Kai-Hei 6-230115 discloses a technology in which the intervehicle distance between an own vehicle and a preceding vehicle is obtained in two ways, one is processing images taken by a stereoscopic camera and the other is directly detecting the distance by a millimeter wave radar. The reliability of the intervehicle distances obtained in the respective ways is investigated based on exterior circumstances and the like and either of the intervehicle distances is selected based on the reliability.

However, the technology disclosed in Toku-Kai-Hei 6-230115 has a disadvantage that since the respective reliabilities of stereoscopic camera and millimeter wave radar are judged simply on the basis of the external circumstances, a proper intervehicle distance is rejected and wrong data are adopted in some cases.

Further, in the prior art, since only one of the two ways is adopted and the other is discarded as invalid, distance data of the vehicle surroundings monitoring apparatus are not efficiently used.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a vehicle surroundings monitoring apparatus capable of monitoring exterior circumstances of a vehicle with high

1 precision by efficiently utilizing both exterior information

2 based on picture images and exterior information obtained from

3 a radar and to provided a traveling control system incorporating

4 such an apparatus.

5   A vehicle surroundings monitoring apparatus for

6 monitoring exterior circumstances and detecting a preceding

7 vehicle traveling ahead of an own vehicle, comprises image solid

8 object detecting means for detecting image solid objects based

9 on image information outputted from a CCD camera, millimeter wave

10 solid object detecting means for detecting millimeter wave solid

11 objects based on signals outputted from a millimeter wave radar,

12 fusion solid object establishing means for establishing fusion

13 solid objects composed of single image solid objects, single

14 millimeter wave solid objects and a combination of the image solid

15 objects and the millimeter wave solid objects by fusing the image

16 solid objects and the millimeter wave solid objects, first

17 reliability judging means for judging a degree of reliability

18 of the fusion solid objects based on a detecting situation of

19 the respective fusion solid objects by the image solid object

20 detecting means, second reliability judging means for judging

21 a degree of reliability of the fusion solid objects based on a

22 detecting situation of the respective fusion solid objects by

23 the millimeter wave solid object detecting means and preceding

24 vehicle selecting means for selecting a preceding vehicle

25 traveling ahead of the own vehicle from the fusion solid objects

1   when it is judged that the fusion solid objects have a specified

2   level of reliability according to either of the first reliability

3   judging means and the second reliability judging means.

4

5   BRIEF DESCRIPTION OF THE DRAWINGS

6   Fig. 1 is a schematic view showing a vehicle

7   surroundings monitoring apparatus according to the present

8   invention and a traveling control system incorporating the vehicle

9   surroundings monitoring apparatus;

10   Fig. 2 is a functional block diagram of a vehicle

11   surroundings monitoring apparatus according to the present

12   invention;

13   Fig. 3 is a schematic illustration of fusion solid

14   objects; and

15   Fig. 4 is a flowchart showing a routine for recognizing

16   a preceding vehicle.

17

18   DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

19   Referring now to Fig. 1, reference numeral 1 denotes

20   a vehicle (own vehicle) on which an intervehicle distance

21   automatically adjusting system (Adaptive Cruise Control: ACC)

22   2 is mounted. The ACC system 2 is constituted by a stereoscopic

23   camera (imaging means) 3, a millimeter wave transmitting and

24   receiving section (radar means) 4, a vehicle surroundings

25   monitoring apparatus 5 and a traveling control unit 6. When the

4

1   ACC system is set to a constant speed control mode, the vehicle

2   travels at a speed established by a vehicle driver and when the

3   system is set to a follow-up traveling control mode, the vehicle

4   travels at a speed targeted to the speed of a preceding vehicle

5   with a constant intervehicle distance to the preceding vehicle

6   maintained.

7   The stereoscopic camera 3 is composed of a pair (left

8   and right) of CCD cameras using a solid-state image component

9   such as Charge Coupled Device and the left and right cameras are

10   transversely mounted on a front ceiling of a passenger compartment

11   at a specified interval of distance, respectively. The respective

12   cameras take picture images of an exterior object from different

13   view points and input image information to the vehicle surroundings

14   monitoring apparatus 5.

15   The millimeter wave transmitting and receiving section

16   4 provided at the front end of the own vehicle 1 transmits millimeter

17   wave (for example radio wave having frequency 30G Hz to 100G Hz)

18   forwardly therefrom and receives reflected millimeter wave,

19   inputting sending and receiving data to the vehicle surroundings

20   monitoring apparatus 5.

21   Further, there is provided a vehicle speed sensor 7

22   in the own vehicle 1 and the detected vehicle speed is inputted

23   to the vehicle surroundings monitoring apparatus 5 and the

24   traveling control unit 6. Further, there are provided a steering

25   wheel rotation angle sensor 8 for detecting steering wheel rotation

5

1 angles and a yaw rate sensor 9 for detecting yaw rates. Signals

2 indicating steering wheel rotation angles and yaw rates are

3 inputted to the vehicle surroundings monitoring apparatus 5.

4 The vehicle surroundings monitoring apparatus 5

5 comprises a stereoscopic image processing section 15 (first solid

6 object detecting means), a distance measuring section 16 (second

7 solid object detecting means), a fusion solid object

8 establishing section 17 (fusion solid object establishing means),

9 an own traveling region estimating section 18 and a preceding

10 vehicle recognizing section 19 (first and second reliability

11 judging means and preceding vehicle selecting means). In this

12 embodiment, those sections work in a coordinate system fixed to

13 the own vehicle 1 of the three-dimensional real space. That is,

14 the coordinate system is composed of X coordinate extending in

15 a widthwise direction of the own vehicle 1, Y coordinate extending

16 in a vertical direction of the own vehicle 1, Z coordinate extending

17 in a lengthwise direction of the own vehicle 1 and an origin of

18 the coordinate placed on the road surface directly underneath

19 the central point of two CCD cameras forming the stereoscopic

20 camera 3. The positive sides of X, Y and Z coordinates are

21 established in a right direction, in an upward direction and in

22 a forward direction, respectively.

23 The stereoscopic image processing section 15 performs

24 various recognitions of lane markers, side walls, solid objects

25 and the like as follows. First, with respect to a pair of

stereoscopic images taken by the stereoscopic CCD camera 4, the stereoscopic image processing section 15 obtains distance information over the entire image from the deviation amount between corresponding positions according to the principle of trianguration and forms a distance image representing three-dimensional distance distribution based on the distance information. Then, based on the distance image, the stereoscopic image processing section 15 extracts lane markers, guardrails, curbs, side walls and solid objects like vehicles by performing the known grouping process, the comparison of the distance image with three-dimensional road profile data, side wall data such as guardrails, curbs and side walls along a road and solid object data such as vehicles and other data which are stored in the memory. Thus extracted lane marker data, side wall data and solid object data are denoted by different numbers for each kind of data, respectively. Further, the solid object data are classified into three kinds of objects, a backward moving object moving toward the own vehicle 1, a still object in standstill and a forward moving object moving in the same direction as the own vehicle 1 based on the relationship between the relative variation of the distance from the own vehicle and the vehicle speed of the own vehicle 1.

When an oncoming vehicle or a preceding vehicle is imaged, generally, its front surface, rear surface, corner part and side surface of a vehicle body are projected on picture images. The

1 stereoscopic image processing section 15 usually extracts the

2 front or rear surface as a solid object and extracts the side

3 surface as a side wall connected through the corner part with

4 the solid object. Accordingly, in case where the extracted solid

5 object is a vehicle, mostly, a side wall connected through a corner

6 part with the solid object is recognized. In case where smear

7 or flare are recognized as a solid object by accident, there is

8 a very small chance that a side wall comes adjacent to the solid

9 object. Accordingly, there is a high possibility that the solid

10 object having two or more surfaces is a vehicle. In the stereoscopic

11 image processing section 3, if the solid object is connected to

12 the side wall through the corner part, the object is registered

13 specially as a corner-like solid object.

14   The distance measuring section 16 performs solidity

15 recognition by processing transmitting and receiving data

16 inputted from the millimeter wave transmitting and receiving

17 section 4 as follows. That is, the distance measuring section

18 16 measures the distance from the own vehicle 1 to the target

19 based on a time between the transmission of a radio wave and the

20 reception of the reflected radio wave. Then, preparing a

21 distribution diagram of distance values, if there is a portion

22 continuously having an identical distance value in the

23 distribution diagram, the portion is extracted and registered

24 as a solid object.

25   The distance measuring section 16 stores the data of

1 the solid object extracted and registered in the previous cycle

2 (this solid object will be referred to as "millimeter wave solid

3 object" hereinafter). When the distance measuring section 16

4 extracts a new solid object in the present cycle (this solid object

5 will be referred to as "detected millimeter wave solid object"

6 hereinafter), the coincidence is judged between the detected

7 millimeter wave solid object and the millimeter wave solid object.

8 That is, in the distance measuring section 16, a coincidence

9 probability P is calculated between the detected millimeter wave

10 solid object and the millimeter wave solid object. If the

11 coincidence probability P exceeds a threshold value, it is

12 judged that the detected millimeter wave solid object is identical

13 to the millimeter wave solid object. In this embodiment, the

14 coincidence probability P is obtained according to the following

15 formulas:

16
17
$$Pz\,(\Delta Z) = \int_{-\Delta Z}^{\Delta Z} 1/(\sqrt{2\pi}\,\sigma z)\, X \exp\,[\,(-Z^2/(2\sigma z^2)\,)\,]\,dz \qquad (1)$$

18

19
20
$$Px\,(\Delta X) = \int_{-\Delta X}^{\Delta X} 1/(\sqrt{2\pi}\,\sigma x)\, X \exp\,[\,(-X^2/(2\sigma x^2)\,)\,]\,dx \qquad (2)$$

21

22
23
$$Pv\,(\Delta V) = \int_{-\Delta V}^{\Delta V} 1/(\sqrt{2\pi}\,\sigma v)\, X \exp\,[\,(-V^2/(2\sigma v^2)\,)\,]\,dv \qquad (3)$$

24

25
$$P = Pz \; x \; Px \; x \; Pv \qquad (4)$$

where $P_z(\Delta Z)$ is a coincidence probability when the difference between the detected millimeter wave solid object n and the millimeter wave solid object m on Z coordinate is ΔZ; where $P_x(\Delta X)$ is a coincidence probability when the difference between the detected millimeter wave solid object n and the millimeter wave solid object m on X coordinate is ΔX; where $P_v(\Delta V)$ is a coincidence probability when the difference of the velocity in the Z direction between the detected millimeter wave solid object n and the millimeter wave solid object m is ΔV; and σz, σx, σv are standard deviations.

In the distance measuring section 16, these calculations are performed with respect to all combinations of the detected millimeter wave solid object and the millimeter wave solid object and the combination whose coincidence probability P exceeds the threshold value (for example 30 %) and is largest, is selected. Further, when it is judged that the detected millimeter wave solid object (present one) is identical to the millimeter wave solid object (previous one), the detected millimeter wave solid object is updated and successively registered as the millimeter wave solid object (previous one). If it is judged that the detected millimeter wave solid object is not identical to the millimeter wave solid object, the detected millimeter wave solid object is registered as a new millimeter wave solid object and the data of the previous one is erased under specified conditions.

1   The fusion solid object establishing section 17 inputs

2   information related to respective solid objects (hereinafter,

3   referred to as "image solid object") from the stereoscopic image

4   processing section 15 and also inputs information related to

5   respective millimeter wave solid objects from the distance

6   measuring section 16. Fusion solid objects are established by

7   fusing these inputted information.

8   Specifically, first, the fusion solid object

9   establishing section 17 judges the coincidence between the

10   respective image solid objects and the respective millimeter wave

11   solid objects. That is, in the fusion solid object establishing

12   section 17, the coincidence probability P is calculated for

13   respective combinations of both solid objects according to the

14   aforesaid formulas (1) to (4) using Z coordinate, X coordinate

15   and the velocity in the Z direction of the respective image solid

16   objects and Z coordinate, X coordinate and the velocity in the

17   Z direction of the respective millimeter wave solid objects. When

18   the image solid object is identical to the millimeter wave solid

19   object, the combination whose coincidence probability P is largest

20   and exceeds a specified value, is determined.

21   Then, the fusion solid object establishing section 17

22   forms respective fusion solid objects by fusing the image solid

23   objects and the millimeter wave solid objects. Referring to Fig.

24   3, fusion solid objects composed of simple image solid objects

25   are illustrated in rectangular shape, fusion solid objects

composed of simple millimeter wave solid objects are illustrated in circular shape, and fusion solid objects composed of the combination of the image solid objects and the millimeter wave solid objects are illustrated in rectangular and circular shape. The respective fusion solid objects include information such as the distance between the fusion solid object and the own vehicle 1, X coordinate, velocity, width and the like of the fusion solid object, and information of the state of movement of forward moving objects, still objects or oncoming vehicles. In case of the fusion solid object composed of the combination of the image solid object and the millimeter wave solid object, information of the millimeter wave solid object is introduced with top priority in establishing the distance between the own vehicle 1 and the solid object, information of the image solid object is introduced with top priority in establishing X coordinate, information of the millimeter wave solid object is introduced with top priority in establishing velocity, and information of the image solid object is introduced with top priority in establishing the width.

Then, after the new fusion solid objects are established, the fusion solid object establishing section 17 makes a coincidence judgment between the newly established fusion solid object and the fusion solid object previously registered. In case of the fusion solid object having coincidence, the fusion solid object is continued to be registered and in case of the fusion solid object having no coincidence, the new fusion solid object

1 is registered and the previous fusion solid object is erased.

2   The own traveling region estimating section 18 inputs

3 signals indicative of vehicle speeds from the vehicle speed sensor

4 7, signals indicative of steering wheel rotation angles from the

5 steering wheel rotation angle sensor 8 and signals indicative

6 of yaw rates from the yaw rate sensor 9, respectively and at the

7 same time inputs lane marker data, side wall data and the like

8 from the stereoscopic image processing section 15, estimating

9 own traveling regions from the own traveling path and the width

10 of lane.

11   In the own traveling region estimating section 18, the

12 traveling path of the own vehicle is estimated according to the

13 following four methods:

14 **Method A: Estimation of traveling path based on lane markers**

15   In case where both or either of left and right lane

16 markers data are obtained and the profile of the lane on which

17 the own vehicle 1 travels can be estimated from these lane markers

18 data, the traveling path of the own vehicle is formed in parallel

19 with the lane markers in consideration of the width of the own

20 vehicle 1 and the position of the own vehicle 1 in the present

21 lane.

22 **Method B: Estimation of traveling path based on side wall data**

23 **such as guardrails, curbs and the like**

24   In case where both or either of left and right side

25 walls data are obtained and the profile of the lane on which the

1　own vehicle 1 travels can be estimated from these side walls data,

2　the traveling path of the own vehicle is formed in parallel with

3　the side walls in consideration of the width of the own vehicle

4　1 and the position of the own vehicle 1 in the present lane.

5　Method C: Estimation of traveling path based on a trace of the

6　preceding vehicle

7　　　　　The traveling path of the own vehicle 1 is estimated

8　based on the past traveling trace of the preceding vehicle.

9　**Method D: Estimation of path based on the trace of the own vehicle**

10　　　　　The path of the own vehicle 1 is estimated based on

11　the traveling conditions such as yaw rate γ, vehicle speed V and

12　steering wheel angle θ H of the own vehicle 1 according to the

13　following steps:

14　　　　　First, it is judged whether or not the yaw rate sensor

15　9 is effective. If it is effective, the present turning curvature

16　Cua is calculated according to the following formula (5).

17　　　　　　　Cua $= \gamma$ /V　　　　　　　　(5)

18　　　　　On the other hand, if the yaw rate sensor 9 is ineffective,

19　it is judged whether or not the vehicle is steered at a steering

20　angle δ more than a prescribed angle (for example 0.57 radian)

21　obtained from the steering wheel angle θ H. In case where the vehicle

22　is steered at a steering angle more than 0.57 radian, the present

23　turning curvature Cua is calculated according to the following

24　formulas (2), (3) using the steering angle δ and the vehicle speed

25　V of the own vehicle 1:

14

1 $$Re = (1 + A \cdot V^2) \cdot (L/\delta) \qquad (6)$$

2 $$Cua = 1/Re \qquad (7)$$

3 where Re is turning radius; A is stability factor of the vehicle;

4 and L is wheelbase of the vehicle.

5   Further, if the steering angle is smaller than o.57

6 radian, the present turning curvature is set to 0 (in a

7 straightforward traveling condition).

8   Then, an average turning curvature is calculated from

9 the sum of thus obtained present turning curvature Cua and a

10 turning curvature for a past prescribed time (for example, 0.3

11 seconds) and the traveling path of the own vehicle is estimated.

12   Even in case where the yaw rate sensor 9 is effective

13 and the turning curvature Cua is calculated according to the formula

14 (5), if the steering angle δ is smaller than 0.57 radian, the

15 present turning curvature Cua may be corrected to 0

16 (straightforward traveling condition).

17   Thus, after the traveling path of the own vehicle is

18 estimated, the own traveling region 18 calculates the width of

19 the lane on which the own vehicle 1 travels.

20   Specifically, in the own traveling region estimating

21 section 18, in case where the own traveling path is estimated

22 according to the method A and the stereoscopic image processing

23 section 15 recognizes both of the left and right lane markers,

24 the space of left and right lane markers is established to be

25 the present lane width. On the other hand, in case where the own

15

1   traveling path is estimated according to the method A and the

2   stereoscopic image processing section 15 recognizes either of

3   the left and right lane markers, an average lane width is

4   established to be the present lane width. Further, in case where

5   the own traveling path is estimated according to either of the

6   methods B, C or D, the lane width 2.2 meters which are established

7   in consideration of modern road situations and the like, is

8   established to be the present lane width. Further, in the own

9   traveling region estimating section 18, after the establishment

10 of the present lane width is completed, the average lane width

11 is calculated from the lane widths accumulated for the past 10

12 seconds within the range between 3.5 meters and 2.2 meters. Thus,

13 the traveling region of the own vehicle 1 is estimated.

14   The preceding vehicle recognizing section 19

15 investigates the reliability as the millimeter wave fusion solid

16 object and the reliability as the image fusion solid object for

17 the respective fusion solid objects moving forward and the

18 intrusion of these respective fusion solid objects into the own

19 traveling region. In case where at least either of these

20 reliabilities has a specified reliability or more and there are

21 fusion solid objects intruding successively into the own traveling

22 region for more than specified time, a forward moving object nearest

23 to the own vehicle 1 is selected as a preceding vehicle from these

24 fusion solid objects.

25   The routine for recognizing the preceding vehicle will

16

1 be described according to the flowchart shown in Fig. 4. The routine

2 is executed every specified time. First, at a step S101, a solid

3 object is selected from the respective fusion solid object

4 established in the fusion solid object establishing section 17.

5 In this embodiment, the fusion solid objects are selected in the

6 order of their proximity from the own vehicle 1.

7 The program goes to a step S102 where the preceding

8 vehicle recognizing section 19 investigates whether or not the

9 fusion solid object presently selected is a forward moving solid

10 object which moves in the same forward direction as the own vehicle

11 1. If it is judged that the fusion solid object presently selected

12 is a forward moving object, the program goes to a step S103 and

13 if it is judged that the fusion solid object is not a forward

14 moving object, the program goes to a step S107.

15 In case where the program goes from the step S102 to

16 the step S103, the preceding vehicle recognizing section 19

17 investigates whether or not the present fusion solid object is

18 a millimeter wave-related fusion solid object, that is, either

19 a single millimeter wave fusion solid object and/or a combination

20 of the millimeter wave fusion solid object and the image fusion

21 solid object. In case where the present fusion solid object is

22 the millimeter wave- related fusion solid object, the program

23 goes to a step S104 in which a millimeter wave registration counter

24 Cm is incremented by one (Cm ← Cm + 1) and then goes to a step

25 S105. On the other hand, in case where it is judged at the step

1   S103 that the present fusion solid object is not a millimeter

2   wave-related fusion solid object, the program goes to a step S105.

3   The program going from the step S103 or the step S104

4   to the step S105, the preceding vehicle recognizing section 19

5   investigates whether or not the present fusion solid object is

6   a corner-related fusion solid object, that is, either a single

7   image fusion solid object or a combination of the millimeter wave

8   fusion solid object and the image fusion solid object and the

9   image solid object constituting the fusion solid object is

10   registered as a corner- like solid object. If it is judged that

11   the present fusion solid object is a corner-related fusion solid

12   object, the program goes to a step S106 where a corner-like

13   registration counter is incremented by one ($Cc \leftarrow Cc + 1$) and goes

14   to a step S107. On the other hand, if it is judged that the present

15   fusion solid object is not a corner-related fusion solid object,

16   the program goes to a step S107.

17   When the program goes from the steps S102, S105 or S106

18   to the step S107, the preceding vehicle recognizing section 19

19   checks whether or not all fusion solid objects are selected. If

20   it is judged that all of the fusion solid objects have not yet

21   selected, the program returns to the step S101 and if it is judged

22   that all of the fusion solid objects have selected, the program

23   goes to S108.

24   At the step S108, the preceding vehicle recognizing

25   section 19 selects a specified forward moving object from

respective fusion solid objects that are judged to be the forward

moving objects at the step S102. The selection of the specified

forward moving object is performed in the order of their proximity

from the own vehicle 1.

Then, the program goes to a step S109 where it is checked

whether or not the presently selected forward moving object

intrudes into the own traveling region. If it is judged that the

presently selected forward moving object intrudes into the own

traveling region, the program goes to a step S110 where an intrusion

counter C_i for counting the number of intrusion into the own

traveling region is incremented by one ($C_i \leftarrow C_i + 1$) and then

the program goes to a step S112. On the other hand, if it is judged

that the presently selected forward moving object does not intrude

into the own traveling region, the program goes to a step S111

where the intrusion counter C_i is cleared ($C_i \leftarrow 0$) and the program

goes to a step S115.

When the program goes from the 110 to the step S112,

the preceding vehicle recognizing section 19 investigates whether

or not the intrusion counter C_i for the forward moving object

Is larger than a preestablished threshold value C_{i1}. That is,

it is investigated whether or not the present forward moving object

intrudes into the own traveling region successively for more than

a specified time. If it is judged at the step S112 that the intrusion

counter C_i is larger than the threshold value C_{i1}, the program

goes to a step S113 and if it is judged that the intrusion counter

Ci is smaller than the threshold value Ci1, the program goes to a step S115.

When the program goes from the step S112 to a step S113, the preceding vehicle recognizing section 19 investigates whether or not the present forward moving object has a higher degree of the reliability with respect to the actual existence than a preestablished degree of reliability by checking whether or not the millimeter wave registration counter Cm is larger than a preestablished threshold value Cm1. That is, the preceding vehicle recognizing section 19 investigates whether or not the forward moving object has a higher degree of the reliability with respect to the actual existence than a preestablished degree of reliability by investigating whether or not the present forward moving object coincides with the millimeter wave fusion solid object with higher frequency than specified. Then, in case where the millimeter wave counter Cm is larger than the threshold value Cm1, the program goes to a step S116 and in case where the millimeter wave counter Cm is smaller than the threshold value Cm1, the program goes to a step S115.

When the program goes from a step S113 to a step S114, the preceding vehicle recognizing section 19 investigates whether or not the forward moving object has a higher degree of the reliability with respect to the actual existence than a preestablished degree of reliability by investigating whether or not the corner-like registration counter Cc for the present

forward moving object is larger than a preestablished threshold value Cc1. That is, the preceding vehicle recognizing section 19 investigates whether or not the forward moving object has a higher degree of the reliability with respect to the actual existence than a preestablished degree of reliability based on the image solid object by investigating whether or not the present forward moving object coincides with the corner-like solid object with a larger frequency than specified. Further, at the step S114, in case where the corner-like registration counter Cc is larger than the threshold value Cc1, the program goes to a step S116 and in case where the corner-like registration counter Cc is smaller than the threshold value Cc1, the program goes to the step S115.

Then, when the program goes from the steps S113 or S114 to the step S116, the preceding vehicle recognizing section 19 registers the present forward moving object as a preceding vehicle, the program leaving the routine.

On the other hand, in case where the program goes from the steps S111, S112 or S113 to the step S115, the preceding vehicle recognizing section 19 investigates whether or not all forward moving objects have been selected. If it is judged that all of the forward moving objects have not yet been selected, the program returns to the step S108 and if it is judged that all of the forward moving objects have been selected, the program leaves the routine without performing the registration of the preceding vehicle.

1   The traveling control unit 6 has a function of the

2   constant speed traveling control for maintaining the vehicle speed

3   at a speed established by the manual input of a vehicle driver

4   and also has a function of the follow-up traveling control for

5   maintaining the intervehicle distance between the own vehicle

6   and the preceding vehicle at a constant distance. Further, the

7   control unit 6 is connected with a constant speed traveling switch

8   10, the vehicle surroundings monitoring apparatus 5 and the vehicle

9   speed sensor 7. Further, the constant speed traveling switch 10

10   includes a plurality of switches connected to an operating lever

11   provided at the side face of a steering column tube.

12   The constant speed traveling switch 10 is constituted

13   by a coast switch for changing the target vehicle speed in a

14   descending direction, a resume switch for changing the target

15   vehicle speed in an ascending direction and the like. Further,

16   there is provided a main switch (not shown) for turning the

17   traveling control on or off in the vicinity of the operating lever.

18   When the driver turns the main switch on and establishes

19   the operating lever to a desired speed, a signal is inputted from

20   the constant speed traveling switch 10 to the traveling control

21   unit 6. The traveling control unit 6 drives a throttle actuator

22   11 based on the signal so as to control the opening angle of a

23   throttle valve 12. As a result, the own vehicle travels

24   automatically at a constant speed.

25   Further, when the vehicle surroundings monitoring

1 apparatus 5 judges that the preceding vehicle travels at a lower

2 speed than that established in the traveling control unit 6 of

3 the own vehicle 1, the traveling control unit 6 automatically

4 changes over the control mode from the constant speed traveling

5 control to the follow-up traveling control in which the own vehicle

6 1 travels with a constant intervehicle distance held.

7   When the traveling control transfers to the follow-up

8 control, the traveling control unit 6 establishes an appropriate

9 target intervehicle distance between the own vehicle 1 and the

10 preceding vehicle on the basis of the intervehicle distance

11 obtained by the vehicle surroundings monitoring apparatus 5, a

12 calculated vehicle speed of the preceding vehicle, and a vehicle

13 speed detected by the vehicle speed sensor 7. The traveling control

14 unit 6 outputs a drive signal to the throttle actuator 11 and

15 adjusts the opening angle of the throttle valve 12 such that the

16 intervehicle distance between the own vehicle 1 and the preceding

17 vehicle agrees with the target intervehicle distance.

18   According to the embodiment of the present invention,

19 the vehicle surroundings monitoring apparatus 5 establishes

20 fusion solid objects composed of single image fusion solid objects,

21 single millimeter wave fusion solid objects, or combinations of

22 the image fusion solid object and the millimeter wave fusion solid

23 object. Further, the vehicle surroundings monitoring apparatus

24 5 investigates the reliability of respective fusion solid objects

25 coinciding with the image solid object and the reliability of

1 respective fusion solid objects coinciding with the millimeter

2 wave solid object. Then, if either of these reliabilities exceeds

3 a reliability respectively established, the fusion solid object

4 is selected as a preceding vehicle. Thus, since both image means

5 and radar means are used concurrently, more accurate surroundings

6 monitoring can be performed.

7 Further, since the reliability of the respective fusion

8 solid objects is performed based on the number of registrations

9 as a corner-like solid object or based on the number of detection

10 as a millimeter wave solid object, the preceding vehicle can be

11 selected with high accuracy.

12 The entire contents of Japanese Patent Application No.

13 Tokugan 2002-278129 filed September 24, 2002, is incorporated

14 herein by reference.

15 While the present invention has been disclosed in terms

16 of the preferred embodiment in order to facilitate better

17 understanding of the invention, it should be appreciated that

18 the invention can be embodied in various ways without departing

19 from the principle of the invention. Therefore, the invention

20 should be understood to include all possible embodiments which

21 can be embodied without departing from the principle of the

22 invention set out in the appended claims.

23